

Proposal # 2001- C204 (Office Use Only)

PSP Cover Sheet (Attach to the front of each proposal)

Proposal Title: Sedimentation-in the Delta and Suisun Bay
 Applicant Name: U.S. Geological Survey
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Amount of funding requested: \$ 1,367,684

Some entities charge different costs dependent on the source of the funds. If it is different for state or federal funds list below.

State cost _____

Federal cost _____

Cost share partners?

____ Yes ☒ No

Identify partners and amount contributed by each _____

Indicate the Topic for which you are applying (check only one box).

- | | |
|---|--|
| <input type="checkbox"/> Natural Flow Regimes | <input type="checkbox"/> Beyond the Riparian Corridor |
| <input type="checkbox"/> Nonnative Invasive Species | <input type="checkbox"/> Local Watershed Stewardship |
| <input checked="" type="checkbox"/> Channel Dynamics/Sediment Transport | <input type="checkbox"/> Environmental Education |
| <input type="checkbox"/> Flood Management | <input type="checkbox"/> Special Status Species Surveys and Studies |
| <input type="checkbox"/> Shallow Water Tidal/ Marsh Habitat | <input type="checkbox"/> Fishery Monitoring, Assessment and Research |
| <input type="checkbox"/> Contaminants | <input type="checkbox"/> Fish Screens |

What county or counties is the project located in? SACRAMENTO, YOLO, CONTRA COSTA,
SAN JOAQUIN, SOLANO

What CALFED ecozone is the project located in? See attached list and indicate number. Be as specific as possible 1, 2, 3.5, 11, 14

Indicate the type of applicant (check only one box):

- | | |
|--|--|
| <input type="checkbox"/> State agency | <input checked="" type="checkbox"/> Federal agency |
| <input type="checkbox"/> Public/Non-profit joint venture | <input type="checkbox"/> Non-profit |
| <input type="checkbox"/> Local government/district | <input type="checkbox"/> Tribes |
| <input type="checkbox"/> University | <input type="checkbox"/> Private party |
| <input type="checkbox"/> Other: _____ | |

Indicate the primary species which the proposal addresses (check all that apply): ALL SPECIES
(SEDIMENTARY HABITATS)

- | | |
|--|--|
| <input type="checkbox"/> San Joaquin and East-side Delta tributaries fall-run chinook salmon | <input type="checkbox"/> Spring-run chinook salmon |
| <input type="checkbox"/> Winter-run chinook salmon | <input type="checkbox"/> Fall-run chinook salmon |
| <input type="checkbox"/> Late-fall run chinook salmon | <input type="checkbox"/> Longfin smelt |
| <input type="checkbox"/> Delta smelt | <input type="checkbox"/> Steelhead trout |
| <input type="checkbox"/> Splittail | <input type="checkbox"/> Striped bass |
| <input type="checkbox"/> Green sturgeon | <input type="checkbox"/> All chinook species |
| <input type="checkbox"/> White Sturgeon | <input type="checkbox"/> All anadromous salmonids |
| <input type="checkbox"/> Waterfowl and Shorebirds | <input type="checkbox"/> American shad |
| <input type="checkbox"/> Migratory birds | |
| <input type="checkbox"/> Other listed T/E species: _____ | |

Indicate the type of project (check only one box):

- | | |
|---|---|
| <input checked="" type="checkbox"/> Research/Monitoring | <input type="checkbox"/> Watershed Planning |
| <input type="checkbox"/> Pilot/Demo Project | <input type="checkbox"/> Education |
| <input type="checkbox"/> Full-scale Implementation | |

Is this a next-phase of an ongoing project?

Yes ☒

No ☐

Have you received funding from CALFED before?

Yes ☒

No ☐

If yes, list project title and CALFED number SEDIMENTATION IN THE DELTA AND SUISON BAY,

Have you received funding from CVPIA before?

Yes ☐

No ☒

If yes, list CVPIA program providing funding, project title and CVPIA number (if applicable):

By signing below, the applicant declares the following:

- The truthfulness of all representations in their proposal;
- The individual signing the form is entitled to submit the application on behalf of the applicant (if the applicant is an entity or organization); and
- The person submitting the application has read and understood the conflict of interest and confidentiality discussion in the PSP (Section 2.4) and waives any and all rights to privacy and confidentiality of the proposal on behalf of the applicant, to the extent as provided in the Section.

RANDAL L. DINEHART

Printed name of applicant

David Schoellhamer

Randal L. Dinehart

Signature of applicant

David Schoellhamer

Executive Summary: -- Sedimentation in the Delta and Suisun Bay

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Cost: \$1,367,684

The primary objectives of this study are to describe the movement of sediment affecting habitats in the Delta and describe the availability of sediment needed for habitat restoration. Sediment transport from the Central Valley periodically adds sediment to channel beds in the Delta; the sediment is subsequently resuspended and transported by tidal flows. New findings on sediment movement from the Central Valley to the Delta have been obtained as sediment-transport data have been collected and analyzed since 1998. Continuous monitoring has shown that, rather than a slow migration from reach to reach, sand is transported rapidly to the Delta during high flows. We are monitoring a range of synoptic sampling sites to determine the variation of sediment-transport related to flows in sensitive habitats. As the next phase commences, we will 1) differentiate sedimentation between dry and normal years, 2) document sediment-transport effects of restoration activities, 3) test geomorphic hypotheses, and 4) improve the conceptual model of sedimentation in the Delta.

HYPOTHESES BEING TESTED - The geomorphic hypotheses propose to explain the limitations of sediment supply and the accumulation of sediment within the study area. Hypotheses will be tested by measuring the annual and flow-related fluctuations in sediment transport within the Delta.

METHODS AND OUTCOME - To understand the availability and quantity of sediment movement through the Delta and Suisun Bay, sediment transport will be monitored at several sites. The two components of the sediment load we evaluate are suspended load (fine sediments moving at the same speed as water) and bedload (sand moving at a slower rate along the bed). The eventual pathways of sediment transport in tidally-dominated channels are being determined by synoptic bedform mapping and concentration monitoring. Suspended-sediment concentration will be measured continuously with optical backscatterance sensors. Bedload movement will be assessed from bedform maps of representative channels. The data will be analyzed to determine the variations in sediment transport that occur with seasonal changes in the watershed, flow magnitude, tidal cycles, and local fluctuations in sediment supply.

A USGS Professional Paper will present interpretations of data collected during both phases of the project and will argue the results of hypothesis testing for geomorphic and operational questions. Sediment records, maps of channel deposition and preliminary results are presented publicly and are being published in data reports and journal articles. Basic results are shown at the USGS Web Site, "Sedimentation in the Delta," at <http://water.wr.usgs.gov/program/sfbay/calfedsed/>

Project Description

Statement of the Problem

PROBLEM - *The primary objectives of this study are to describe the movement of sediment affecting habitats and describe the availability of sediment needed for habitat restoration.* The Sacramento-San Joaquin River Delta was formed by deposition of sediment transported through the Central Valley of California. Ecologists understand that sand and fine sediment move into the Delta, but the sedimentation data collected and interpreted with this project allows ecosystem restoration personnel to assess the availability, quantity, and efficient use of sediment. Environmental stresses on floodplain, marshplains, and stream channels can be counteracted by artificial and natural movement of sediment. Because sediment is the raw material for habitat restoration projects, this project assists CALFED in improving and expanding aquatic and terrestrial habitats. The physical foundation of the CALFED priority habitats ranges from gravel and cobble riverbeds (often overlain by sand) to muddy estuarine deposits. Information prepared on sediment movement through stressed habitats of the Delta will refine design criteria for restoration projects.

CONCEPTUAL MODEL - *Sediment transport from the Central Valley periodically adds sediment to channel beds in the Delta; the sediment is subsequently resuspended and transported by tidal flows.* Before the first phase of this sedimentation study, there was little investigation of the time lag between sediment transport from the delivering streams and sediment deposition in the Delta. The two components of the sediment transport in Central Valley rivers and the Delta are suspended sediment (fine sediments moving at the same speed as water) and bedload (sand moving at a slower rate along the bed). Since 1998, continued monitoring has shown that suspended sediment and bedload movement during high discharges in the Sacramento River soon dominate sediment transport in the lower Delta. At high discharges, fine sediments are mobilized and sand is suspended from the Sacramento River streambed; the resulting sediment pulses have been traced along the river course to its junction with the San Joaquin River. The phasing of tides and high discharges determine the time between peak sediment concentrations at various sites. Larger sediment pulses are observed at Mallard Island, near the confluence of the Sacramento and San Joaquin Rivers.

Suspended load varies annually with the quantity and timing of freshwater discharge. Depending on the magnitude of the freshwater discharge, sediment can be deposited in the Delta or carried to the Pacific Ocean. Tides and the complex channel geometry of the Delta complicate suspended-sediment transport in the Delta. The tidal variability in suspended load in the western Delta is much greater than the tidally-averaged suspended load. During high discharges from winter rainstorms, sediment pulses from the rivers can deposit sediment in the shallow subembayments of Suisun and San Pablo Bays (Krone 1979). The newly arrived sediment in the shallow water is repeatedly suspended by tidal currents to elevate sediment concentrations, which persist in shallow water longer than in

the main channel (Ruhl and Schoellhamer 1999). Spring winds also resuspend sediment in the shallow subembayments, raising concentrations. As the winds persist through the summer, fine sediment is winnowed from the bed and the effect of wind-wave resuspension on sediment concentration diminishes.

In Suisun Bay, areas of maximum turbidity (Estuarine Turbidity Maxima) are located near sills and sometimes near a salinity of 2, depending on tidal phase and the spring/neap tidal cycle (Schoellhamer and Burau 1998, Schoellhamer in press). Where turbidity maxima occur in estuaries, accumulations are found of suspended sediment, nutrients, phytoplankton, zooplankton, larvae, and juvenile fish (Peterson and others 1975, Arthur and Ball 1979, Kimmerer 1992, Jassby and Powell 1994, Schoellhamer and Burau 1998). Increased suspended sediment limits the availability of light in San Francisco Bay and Delta, which, in turn, limits photosynthesis and primary photosynthetic carbon production (Cole and Cloern, 1987; Cloern, 1987, 1996).

Bottom sediments, which support benthic organisms, are a reservoir of nutrients that help maintain estuarine productivity (Hammond and others 1985). Potentially toxic substances, such as metals and pesticides, adsorb to sediment particles that eventually settle (Kuwabara and others 1989; Domagalski and Kuivila 1993; Flegal and others, 1996; Schoellhamer 1997). Benthic organisms can ingest these substances from bottom sediments and introduce them into the food web (Luoma and others, 1985; Brown and Luoma, 1995; Luoma, 1996).

Sand is primarily transported as bedload along the bottom of large, slow rivers such as the Sacramento and San Joaquin. In most reaches of the Delta, sand transport is revealed by the presence and movement of sand dunes. The mechanics of sediment movement along channels is widely understood (Middleton and Southard, 1984), but the geomorphic context is unpredictable. Before the present study observed sand transport at high discharges, anecdotal evidence suggested that reduced flows and reservoir trapping had restricted sand transport in the river-delta system, with sand bars present only as relicts of rare floods. Our present model describes a more dynamic system that transports sand annually at high discharges to the Delta, into regions that show sudden deposition and changes in bed configuration. The present model still cannot account for the primary sources of sandy sediment (main channel or upland sources), nor the extent of sediment starvation (random/systematic variation or decadal trends).

HYPOTHESES BEING TESTED –

The geomorphic hypotheses propose to explain the limitations of sediment supply and the accumulation of sediment within the study area. By measuring the annual and flow-related fluctuations in sediment transport within the Delta, more specific questions of supply limitation and accumulation can be answered.

Limitations of sediment supply

Confirmation of decadal trends. The primary sedimentation process of recent geologic

history in the Central Valley has been the occurrence and cessation of hydraulic mining for gold in the Sierra Nevada, and the accompanying movement of river detritus to San Francisco Bay (Gilbert, 1917; Cappiella and others, 1999). Transport rates for suspended sediment have been shown to decline for the period of record from 1960 to present (Oltmann and others, 1999). Is the sediment supply of the Sacramento River in a century-long decline from the initial surge of hydraulic-mining debris? Have extreme floods in 1964 and 1986 caused disturbances to equilibrium transport that are now being detected as decadal declines? Or have the reservoir impediments, land-use changes and channel revisions been the primary causes of the detected trends? These causes are not mutually exclusive, so monitoring will be adjusted to discriminate possible sources.

Erosion may increase with changes to tidal prism. Restoration of tidal wetlands may trap sediment and increase the tidal prism within the Delta. Altered freshwater flow regimes may increase or decrease the supply of sediment to the Delta. As restoration proceeds, we propose to monitor changes in sediment transport that will ultimately create additional landscape changes within the Delta. For example, diminished sediment supply and increased tidal energy could cause increased erosion and possible loss of existing desirable habitats.

Flow thresholds, bed degradation, and sediment depletion. During winter months of year 2000, the threshold discharge for widespread suspension of sand bed material from a surveyed section of the lower Sacramento River was identified as about 40,000 cfs (Dinehart, in review). The changes in bedform regime from dunes to low-relief bedforms are correlated with discharge to show when bed material is eroded to lower levels and suspended for longer durations in the water column. One hypothesis to be tested is that increased flow erodes the streambed to the same degree in most reaches during high flows. This will require rapid channel surveys to view the lower river as a whole so that the extent of riverbed changes can be seen for the period of high flow.

Records of suspended sediment concentration show an extended increase during high discharges. The records may represent a pulse of suspended sand that passes directly to the Delta as the bed material is suspended. At high discharges, the associated nutrients and contaminants buried in the riverbed become available for rapid transport to the Delta. Larger pulses of sediment are recorded at Mallard Island (where waters of the Delta and Suisun Bay mix), but concentrations of suspended sediment soon reach an annual minimum. The decrease in concentration, once thought to represent dilution by high discharges and reservoir releases, may instead show depletion of mobile sediment for suspension, corresponding to the bed degradation measured further upstream. Tracking of sediment pulses and computation of sediment flux will test the hypotheses of sediment depletion and dilution, and resolve the seasonal deposition of degraded channels.

Sediment Accumulation

Transport pathways in tidally-dominated channels. Our measurements of sediment transport identify periods and locations of sediment convergence and accumulation. In order to create stable habitats and construct levees, the regions where sediment

converges, deposits, and accumulates must be known over annual time scales. Preferred zones of sediment deposition are related to changes in channel geometry and at flow junctions. Previously unmapped deposits were found at the northern entrance to Three Mile Slough, possibly from velocity decreases caused by tidal cycles at the channel expansion. At the southern entrance to Three Mile Slough, sand shoals indicate that sediment from the Slough is transported several miles up the San Joaquin River before migrating to Suisun Bay and beyond. Are these deposits seasonal, and would dredging of sediment from one zone affect the rate of replenishment at another? The question will be tested by measuring sediment transport at adjacent zones to determine the transport direction.

The relation between Estuarine Turbidity Maxima and X2. Physical processes within the low salinity zone of Suisun Bay create convergence and entrapment that is ecologically beneficial. Suspended-sediment concentration monitoring in Suisun Bay has provided the basis for improvement for our understanding of ETMs and will continue to provide essential data needed to understand the physical processes underlying ETMs and the X2 relationships.

Uncertainties Being Investigated

Our results to date indicate patterns of transport of sediment and sediment-associated contaminants. Thus, our results will be useful in attaining ecosystem-restoration goals for protection and restoration of habitat and for improvement and maintenance of sediment and water quality. Sediment-transport measurements are designed to clarify the mechanisms associated with listed uncertainties

- natural flow regimes (geomorphic flow thresholds),
- physical basis for the X2 relationships,
- declining productivity (riverine inputs and contaminants),
- non-native invasive species (bioaccumulation of sediment-associated contaminants in Asian clams within ETMs),
- channel dynamics and sediment transport (shoals at entrances and expansions, erosion and deposition at bends),
- flood management as an ecosystem tool (flushing flows),
- and the fate of sediment-associated contaminants from the Central Valley (resuspension of buried contaminants with bed movement).

ADAPTIVE MANAGEMENT- The primary product of this project is knowledge of sediment transport through the Delta required to inform future decision making. We understand the basic movement of sediment into the Delta, but we are now collecting original data for evaluating present conditions and future changes. The CALFED Sedimentation project helps specify conceptual models of habitat change, provides learning from restoration actions, monitoring of the effects of restoration, and assessment and evaluation of sedimentation changes (figure 2, PSP). Data collection and analysis will resolve the sedimentation components of the scientific uncertainties. Because the connections between sediment supply and deltaic sedimentation are so complex, no physical model can be built to test our hypotheses. Instead, we are monitoring the Delta

at a range of flow conditions that test the behavior of the prototype.

This sediment-monitoring program for the Delta can continue and improve as the Delta and Suisun Bay are restored. The many channels of the Delta are wide with irregular cross sections; because the channel beds are most active during only a few weeks of the year, the allocation of boats and personnel for monitoring is necessarily limited. As the relative value of sampling sites is identified, boats and personnel are concentrated where sediment data of the widest applicability can be collected. After several peak flows of sediment transport are recorded, and sedimentation through the Delta is described more definitively, the experimental design can easily be modified. Bedform fields can be mapped at virtually any time interval, flow condition and location, and suspended-sediment sensors are portable and programmable for re-deployment at different sites. Thus, our data collection efforts can be shifted to support new designs and monitor specific restoration projects.

Proposed Scope of Work

Geographic Boundaries of the Project – As suggested in the project title, sedimentation in the Delta and Suisun Bay is assessed at sampling sites in ecozones 1, 2, 3.5, 11 and 14. The suspended-sediment sampling sites are:

- Sacramento River at Freeport
- Sacramento River at Rio Vista
- San Joaquin River at Stockton
- San Joaquin River at Jersey Point
- Three Mile Slough near San Joaquin River
- Mallard Island
- Carquinez Strait

The reaches mapped for bedform transport and channel configuration are:

- Sacramento River at Garcia Bend
- Sacramento River at Freeport Bend
- Sacramento River from Rio Vista to Horseshoe Bend
- Three Mile Slough
- False River near San Joaquin River
- Mokelumne River above Highway 12
- San Joaquin River from Three Mile Slough to Seven Mile Slough

Approach

The methodology developed to monitor sedimentation in the Delta has been adapted from well-known, but under-utilized, approaches. Given the complexity of hydraulics in the Delta channels, we have chosen to use continuously recording, submersed OBS sensors rather than daily sampling; instead of periodic bedload sampling, we map bedforms to determine bedform transport and bed regime. As we examine our results, we improve our use of bedform mapping and sediment-concentration monitoring.

Methods for data collection and analysis have been developed during this and other studies of San Francisco Bay (Buchanan and Ruhl 2000, Dinehart and Schoellhamer 1999) and long-term studies of sediment transport in rivers (Dinehart 1997), and in studies of bedform transport in other river estuaries (Kostaschuk and others 1989). Suspended-sediment concentration will be measured with an optical backscatterance sensor, which provides a good record of variability without the expense of repetitive water sampling. Bedform transport will be calculated from bedform profiles by using mean height and movement of dunes. Bed-regime thresholds will then be calculated based on these measurements. The data will be analyzed to determine the variations in sediment transport that occur with seasonal activities in the watershed, flow magnitude, tidal cycles, and local fluctuations in sediment supply. A more complete description is available at the project web site -- <http://water.wr.usgs.gov/program/sfbay/calfedsed/>.

Time series of sediment discharge (mass per unit time) will continue to be derived from monitoring at several sites in the Delta and Suisun Bay. To provide the most information, monitoring sites coincide with locations of hydrodynamic and water-quality measurements presently made by the USGS and other agencies.

Suspended load will continue to be measured at Freeport, Rio Vista, Three Mile Slough, Stockton, and Jersey Point. At each of these sites, the USGS presently measures water discharge (Oltmann 1998). The USGS has determined the daily mean suspended-sediment discharge at Freeport for many years. The instrument at Freeport improves this value and measures variations in sediment transport from backwater, tidal cycles, and floods.

In addition to the permanent stations, instrument packages will be deployed at certain critical times and locations to help address our hypotheses and support other CALFED projects. The instrument packages can be deployed for up to 3 months and measure water velocity, water depth, temperature, salinity, and suspended-sediment concentration (SSC). To measure water discharge and suspended-sediment load from the Yolo Bypass, a submersible instrument package will be deployed in Cache Slough during each wet season. To assist planning for a CALFED pilot restoration project at Twitchell Island, an instrument package will be deployed in the San Joaquin River during a dry season.

Concurrent data from Suisun Bay and the Delta are required to describe the movement of sediment needed for restoration projects. Suspended-solids concentration will continue to be monitored at Mallard Island and Carquinez Strait (Buchanan and Ruhl 2000). Gravitational circulation provides a pathway for sediments and associated contaminants from Carquinez Strait, Napa River, and San Pablo Bay to move into Suisun Bay and the Delta (Schoellhamer and Burau 1998).

In order to map channel bedforms over larger areas more efficiently, improved sonar hardware and software is being obtained, with a cost still about a tenth of contemporary hydrographic-surveying systems. Some provision for measuring flow during surveys at ungaged sites will be made to give more exact data for flow thresholds.

Data Handling and Storage – The USGS is well-equipped to handle and store data from gaging stations and water studies. An integrated network of computers is used to distribute data throughout the agency and allow processing of data for publication. Detailed hydraulic and sedimentologic data not recorded to the network are archived in several formats (periodic backups, multiple drive storage) before publication.

Data recorded at continuous monitoring sites for suspended load are downloaded from a data logger onto a storage module during site visits. Raw data from the storage modules are loaded into the USGS automated data-processing system (ADAPS). The time-series data are retrieved from ADAPS and edited using MATLAB software to remove invalid data. Invalid data includes rapidly increasing voltage outputs and unusually high voltage outputs of short duration. As biological growth accumulates on the optical sensors, the voltage output of the sensors increases. The edited data are converted to cross-sectionally averaged suspended-sediment concentration and stored in ADAPS. ADAPS data are archived for future access. Buchanan and Ruhl (2000) discuss details of data handling and storage.

Bedform surveys are processed from lat-long coordinates to state plane coordinates, with depths calculated as bed elevations corrected from water-surface elevation at gaging stations. Final surveys are archived in USGS computers and on CD, with summary versions released in popular formats (x, y, z in MS Excel spreadsheets). Bedform maps are interpreted from surveys by common algorithms (finite-element triangulation of irregular points; uniform grids interpolated by kriging) and results are readable by commercial software. Computations from bedform measurements and profiles are retained for internal analysis and review, with summary results released for publication.

Expected Products – A USGS Professional Paper will present interpretations of data collected during both phases of the project and will argue the results of hypothesis testing for geomorphic and operational questions. Publications and public presentations include:

- Regular additions to the project web page
<http://water.wr.usgs.gov/program/sfbay/calfedsed/>
- Quarterly reports
- Interim Fact Sheets
- SSC data reports
- Bedform-mapping methods papers
- Professional Paper
- CALFED Science Conferences
- Public lectures and outreach activities
- Consultations with CALFED staff and stakeholders
- Collaboration with other Bay and Delta projects including CALFED restoration projects, IEP, and RMP.

Work Schedule – All tasks (data collection, analysis, and report preparation) are performed concurrently.

Feasibility - Our approach has already proven to be feasible in the Bay and Delta. Suspended-sediment concentration monitoring methods originally developed for use in the Bay (Buchanan and Ruhl 2000) have successfully been modified to measure suspended-sediment load in the Delta. Instruments are deployed from existing structures or piles, so no additional permits are required.

Bedform mapping has been used to calculate bedform transport. Bedform-transport measurements have been tested extensively in flume and field experiments, especially estuaries, and have been found to yield results similar to other methods of bedload-transport measurement (Crickmore, 1967; Engel and Lau, 1980; van den Berg, 1987; Dinehart, 1992). Objections in the literature to the method are known, which usually are based on the overpassing of bedforms by sediment at higher velocities. Bedforms in the Delta are usually two-dimensional (straight crested) and are measured at low velocities. For those conditions, bedform- and bedload-transport rates are comparable (Rubin and Hunter, 1982). Comparable objections in the literature have been made to bedload transport derived from bag samplers (Gaweesh and van Rijn, 1994; Gomez and Troutman, 1997), which are based on the tendency to scoop material, or on the large number of samples required for meaningful rates. For the purposes of this study, we choose the minor errors and low cost of bedform mapping over the extreme costs required to reduce errors of conventional bedload sampling.

Applicability to CALFED ERP Goals and Implementation Plan and CVPIA Priorities

ERP Goals and CVPIA Priorities. – Sedimentation processes described by this project will contribute to efforts on Goal 3, maintaining and enhancing anadromous fish populations, by documenting the process of streambed disruption and recovery during high discharges.

Because sediment is the raw material for habitat restoration projects, this project assists CALFED with Goal 4, protecting or restoring aquatic and terrestrial habitats. The physical foundation of the CALFED priority habitats ranges from gravel and cobble riverbeds (often overlain by sand) to muddy estuarine deposits. Information prepared on sediment movement through stressed habitats of the Delta will refine design criteria for restoration projects. Goal 6, improvement and maintenance of water and sediment quality benefits directly from the data collection and analysis of this CALFED Sedimentation project. The sediment transported to the Delta includes all varieties of adherents, including nutrients, toxic metals and organic compounds. Only by continuous observation of sediment transport through the range of flows can the transport variation of adherents be determined.

Relationship to Other Ecosystem Restoration Projects – This proposal anticipates next-phase funding to continue measurement and analysis of sediment transport. The project provides knowledge of the movement and availability of sediment for the use of other CALFED restoration projects.

We have assisted the Twitchell Island restoration project in identifying locations of sediment convergence in the lower San Joaquin River at which they will construct a sediment trap. We are proposing to deploy instruments to help them determine the rate of sediment replenishment in the lower San Joaquin River. A study of dissolved organic carbon release from Delta wetlands will modify our techniques to measure water, carbon and sediment fluxes. CALFED has funded several projects studying mercury, which is associated with sediment particles. Sediment transport is a pathway for mercury transport. The CALFED project 'Assessment of Ecological and Human Health Impacts of Mercury in the Bay-Delta Watershed' will be assessing loading of mercury and methyl mercury from Cache Creek to the Yolo Bypass and Delta. Proposed CALFED projects intend to use our suspended-sediment concentration data to develop numerical transport models of mercury (Andy Bale, Larry Walker and Associates) and to help quantify mixing of selenium from the San Joaquin River with Sacramento River water (Sam Luoma, Jim Cloern, Lisa Lucas, USGS). Sediment transport measurements by this project and the McCormack-Williamson Tract Restoration Planning, Design and Monitoring Program will be mutually beneficial. Our project provides continuous monitoring of SSC and suspended load in the Delta, which helps to provide context and fill the data gaps of CALFED, IEP, and RMP water quality projects that sample less frequently.

The Army Corps of Engineers surveys channels for bathymetric purposes and to obtain flow-modeling boundaries for its Comprehensive Study. However, the bedform mapping and riverbed profiling of the CALFED project is highly detailed compared to the broad, infrequent surveys of the Comprehensive Study. Instead, riverbed reaches are mapped at various discharges over short

time intervals for transport measurements and identification of flow regimes.

Request for Next-Phase Funding – (see Appendix for existing project status)

We propose to continue monitoring sedimentation and analyzing transport pathways in relation to discharge and tidal levels. During the first phase of the project, we established data collection methods and sites and began to collect suspended and bed load data. These data have 1) established a baseline for wet years, 2) revealed aspects of sedimentation in the study area, 3) caused us to formulate specific hypotheses, and 4) guided our conceptual model. Additional data collection and analysis will 1) differentiate sedimentation between dry and normal years, 2) document sediment-transport effects of restoration activities, 3) test existing hypotheses on the movement and availability of sediment needed for habitat restoration, and 4) improve the conceptual model of sedimentation in the Delta. Presently, project workers are collecting data, analyzing previously collected data, and writing data and interpretive reports. The present project termination date has been extended from September 30, 2000, to June 30, 2001. This extension permits us to continue report preparation, which was rescheduled because of funding delays. Data collection after September 30, 2000, is not included in the extension but is included in this proposal. The progress of the project is described in greater detail in the appendix to the proposal, in reports submitted quarterly to CALFED, and at the project web site "Sedimentation in the Delta," <http://water.wr.usgs.gov/program/sfbay/calfedsed/>.

Previous recipients of CALFED funding - Schoellhamer and Dinehart are the principal investigators for the CALFED project entitled "Sedimentation in the Delta and Suisun Bay," CALFED number 1997-B02, the status of which is described in the preceding section and appendix. Schoellhamer is also one of the principal investigators on the CALFED project "Dissolved organic carbon release from Delta wetlands: amounts, alterations, and implications for drinking water quality and the Delta foodweb; Part II – fluxes and loads from tidal and non-tidal wetlands and from agricultural operations." This project has been approved but the contracts have not been completed.

System-Wide Ecosystem Benefits – This project provides indirect system-wide ecosystem benefits because it complements several other non-CALFED programs and projects from the watershed to the Bay. The USGS monitors sediment transport in several tributaries to the Delta. The Regional Monitoring Program for Trace Substances supports SSC monitoring stations in Central and South San Francisco Bays. The sediment monitoring associated with this proposal supports stations in Suisun Bay and the Delta, thus completing the network throughout the watershed. This project calculates suspended load and interprets bed load data within the study area by utilizing flow data collected by the USGS and supported by the Interagency Ecological Program (IEP). Project data also support Suisun Bay studies by the IEP (entrapment zone) and USGS (flow/sediment/contaminants). The ability to document the erosion of sand to the level of existing lag deposits during high flow may permit "flushing flows" to be sent through the Sacramento River system without overuse of water.

Qualifications

Dr. David Schoellhamer will be responsible for overseeing measurements of suspended-sediment transport and for interpreting the measurements. Since 1993, he has been conducting sediment transport research in San Francisco Bay for the USGS in cooperation with the CALFED Bay/Delta Program, San Francisco Regional Water Quality Control Board, U.S. Army Corps of Engineers, Regional Monitoring Program for Trace Substances, California Coastal Conservancy, and the Interagency Ecological Program. Many publications and technical presentations have resulted from this work (see section I., Literature Cited and a complete listing at <http://water.wr.usgs.gov/abstract/sfbay/sfbaycontbib.html>). From 1987 to 1993 he conducted a study of sediment resuspension in Tampa Bay, Florida, for the USGS. Dr. Schoellhamer earned his doctorate in Coastal and Oceanographic Engineering from the University of Florida in 1993 and Bachelor and Master of Science degrees in Civil Engineering from UC Davis in 1982 and 1983. He also teaches a graduate-level class in sediment transport for the Department of Civil and Environmental Engineering at UC Davis.

Randal Dinehart is a USGS research hydrologist and will be responsible for measurements of bedform transport and interpretation of channel conditions. He has 25 years of experience in riverine sediment-transport measurement and analysis, including 12 years of applied research at Mount St. Helens, where he measured bedload transport and bedform migration rates; he wrote several reports, research articles, and the USGS Professional Paper on sediment transport in the region. His B.S. degree was earned at the University of Washington in 1977 in Hydrologic Engineering and Technical Communication. Following graduate work at the University of Minnesota in 1994 in sediment transport, he published field research on river turbulence while beginning his investigations of sand transport in the lower Sacramento River.

Paul Buchanan will continue to be responsible for the operation of the suspended-sediment transport stations. He has worked for the U.S. Geological Survey as a Hydrologic Technician since 1988, he has collected data in San Francisco Bay since 1992, and he has directed the installation and operation of this project's Delta suspended-sediment transport stations. He has been responsible for maintaining similar monitoring stations in San Francisco Bay since 1993 and he has written several reports that summarize data collected at the bay stations (see section I., Literature Cited and a complete listing at <http://water.wr.usgs.gov/abstract/sfbay/sfbaycontbib.html>). He received his Bachelor of Science degree from California State University, Sacramento, in 1988.

Cost

Budget: Total cost for the project is \$1,367,684 over 3 years. The present phase of the project was extended until June 30, 2001 in order to complete reports. Thus, data analysis for FY2001 is smaller than future years because some of these expenses are

2001 PSP Budget Tables. Sedimentation in the Delta and Suisun Bay												
Table 1. Budget.												
Year	Task	Direct Labor Hours	Salary and Benefits	Cellular Phones	Equipment	Instrument Repairs	Overtime	Printing	Reports staff	Sediment Lab		
FY 2001	Bedforms: measurement	712	\$21,497	\$0	\$25,000	\$0	\$500	\$0	\$0	\$0		
	Bedforms: analysis	1230	\$44,566	\$0	\$0	\$0	\$0	\$0	\$8,077	\$0		
	Susp. load: measurement	2360	\$60,725	\$1,000	\$0	\$1,000	\$1,000	\$0	\$0	\$16,160		
	Susp. Load: analysis	0	\$0	\$0	\$0	\$0	\$0	\$100	\$7,491	\$0		
Total Cost FY2001		4,302	\$126,788	\$1,000	\$25,000	\$1,000	\$1,500	\$100	\$15,568	\$16,160		
FY 2002	Bedforms: measurement	712	\$23,002	\$0	\$0	\$0	\$500	\$0	\$0	\$0		
	Bedforms: analysis	1752	\$67,534	\$0	\$0	\$0	\$0	\$0	\$8,035	\$0		
	Susp. load: measurement	2360	\$64,976	\$1,000	\$0	\$1,000	\$1,000	\$0	\$0	\$16,160		
	Susp. Load: analysis	660	\$31,307	\$0	\$0	\$0	\$0	\$1,000	\$10,407	\$0		
Total Cost FY2002		5,484	\$186,819	\$1,000	\$0	\$1,000	\$1,500	\$1,000	\$18,442	\$16,160		
FY 2003	Bedforms: measurement	712	\$24,507	\$0	\$0	\$0	\$500	\$0	\$0	\$0		
	Bedforms: analysis	1752	\$71,588	\$0	\$0	\$0	\$0	\$1,000	\$8,560	\$0		
	Susp. load: measurement	2360	\$69,227	\$1,000	\$0	\$1,000	\$1,000	\$0	\$0	\$16,160		
	Susp. Load: analysis	660	\$32,968	\$0	\$0	\$0	\$0	\$2,000	\$10,960	\$0		
Total Cost FY 2003		5,484	\$198,290	\$1,000	\$0	\$1,000	\$1,500	\$3,000	\$19,520	\$16,160		
Total Project Cost		15,270	\$511,897	\$3,000	\$25,000	\$3,000	\$4,500	\$4,100	\$53,530	\$48,480		

Table 1. Budget.						
Shipping	Supplies	Travel	Vehicles and boat gas	Subtotal	Overhead (89.25% of net)	Total Cost
\$0	\$6,000	\$500	\$2,800	\$56,297	\$50,249	\$106,546
\$100	\$0	\$0	\$0	\$52,743	\$47,077	\$99,820
\$1,000	\$8,000	\$1,000	\$3,650	\$93,535	\$83,487	\$177,022
\$0	\$0	\$0	\$0	\$7,591	\$6,775	\$14,366
\$1,100	\$14,000	\$1,500	\$6,450	\$210,166	\$187,589	\$397,755
\$0	\$6,000	\$500	\$2,800	\$32,802	\$29,278	\$62,080
\$100	\$0	\$0	\$0	\$75,669	\$67,540	\$143,209
\$1,000	\$8,000	\$1,000	\$3,650	\$97,786	\$87,281	\$185,067
\$0	\$0	\$0	\$0	\$42,714	\$38,126	\$80,840
\$1,100	\$14,000	\$1,500	\$6,450	\$248,971	\$222,226	\$471,197
\$0	\$6,000	\$500	\$2,800	\$34,307	\$30,622	\$64,929
\$100	\$0	\$0	\$0	\$81,248	\$72,520	\$153,767
\$1,000	\$8,000	\$1,000	\$3,650	\$102,037	\$91,076	\$193,113
\$0	\$0	\$0	\$0	\$45,928	\$40,995	\$86,923
\$1,100	\$14,000	\$1,500	\$6,450	\$263,520	\$235,212	\$498,732
\$3,300	\$42,000	\$4,500	\$19,350	\$722,657	\$645,026	\$1,367,684

Table 2. Positions, Salary, and Benefits for each task, FY2001										
Position	Research Hydrologist	Research Hydrologist	Super. Hyd. Tech	Hydrologic Technician	Hydrologic Technician	Hydrologic Technician	Hydraulic Engineer	Gage Stn Const Work	Total	
Hourly Rate	\$45.89	\$36.23	\$29.81	\$24.78	\$23.09	\$21.05	\$29.78	\$24.88		
Benefits	20%	15%	21%	22%	27%	27%	21%	20%		
Bedforms: measurement	0	336	0	336	0	0	0	40	712	
Bedforms: analysis	0	1,230	0	0	0	0	0	0	1,230	
Susp. load: measurement	80	0	520	520	520	520	160	40	2,360	
Susp. Load: analysis	0	0	0	0	0	0	0	0	0	
Total Hours	80	1,566	520	856	520	520	160	80	4,302	
Total cost	\$3,671	\$56,736	\$15,501	\$21,212	\$12,007	\$10,946	\$4,765	\$1,990	\$126,828	
Table 3. Positions, Salary, and Benefits for each task, FY2002										
Position	Research Hydrologist	Research Hydrologist	Super. Hyd. Tech	Hydrologic Technician	Hydrologic Technician	Hydrologic Technician	Hydraulic Engineer	Gage Stn Const Work	Total	
Hourly Rate	\$48.89	\$38.60	\$31.76	\$26.40	\$24.60	\$22.42	\$31.73	\$26.51		
Benefits	20%	15%	21%	22%	27%	27%	21%	20%		
Bedforms: measurement	0	336	0	336	0	0	0	40	712	
Bedforms: analysis	0	1,752	0	0	0	0	0	0	1,752	
Susp. load: measurement	80	0	520	520	520	520	160	40	2,360	
Susp. Load: analysis	620	0	40	0	0	0	0	0	660	
Total Hours	700	2,088	560	856	520	520	160	80	5,484	
Total cost	\$34,223	\$80,597	\$17,786	\$22,598	\$12,792	\$11,658	\$5,077	\$2,121	\$186,852	

covered by the extension. Travel costs are related to field work. Supplies are primarily for hardware and batteries needed to deploy instruments in the field. Equipment purchases during the first year are to upgrade the bedform profiler, providing more accuracy and more efficient data handling. Overhead includes, but is not limited to, administration, clerical, computing, data base management, space, technical assistance and support. The overhead rate for federal funds is 89.3% of net. The overhead rate for state funds is 98.8% of net. We have used the federal funds rate because it is smaller and we presently receive federal funds. We have not included a separate project management task because this is not a construction project and our project management costs are small and are built into our individual tasks.

Cost-sharing: This proposal does not involve any direct cost sharing funds. Data on water discharge in the Delta collected by the USGS and IEP is essential to this project and the availability of those data greatly reduce the cost of this project. Data from USGS sediment monitoring stations at Freeport and Vernalis and DWR/IEP water level stations in the Delta are also used by this project and reduce the cost of this project.

Local involvement

This project involves data collection and analysis and has no adverse or third party impacts.

Compliance with Standard Terms and Conditions

We will comply with federal standard terms. Project costs are reduced with federal funds and our present funding is federal, so we assume that our source of funding would continue to be federal.

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Appendix – Existing Project Status

The U.S. Geological Survey (USGS) is measuring the transport of sands by volumetric methods; the flux of fine sediments from the tributary rivers is monitored by optical backscatterance sensors and calculated using hydraulic data. Preliminary project results were presented to CALFED staff and other interested parties on February 2, 2000.

Accomplishments:

The USGS has established a network of 13 sites in the delta and bay at which suspended-solids concentration is monitored. Optical backscatterance sensors are deployed at each site and sampled every 15 minutes. Water samples are collected periodically and analyzed for suspended-solids concentrations, which are used to calibrate the sensors. The transport of fine sediments by river discharge and tidal fluctuation has been tracked past the various river and delta sites to San Francisco Bay.

Cross-sectionally averaged suspended-sediment concentration is measured every 15 minutes at Freeport, Rio Vista, Three Mile Slough, Dutch Slough, Stockton, and Jersey Point. Time-series of cross-sectionally averaged suspended-sediment concentration collected at these sites are multiplied by ultrasonic velocity meter measurements of water discharge to determine the time series of suspended-sediment load. Suspended-sediment concentration was measured every 15 minutes at Mallard Island and Carquinez Strait. These time series are being analyzed to determine suspended-sediment transport processes in the Delta and Suisun Bay.

Riverbed profiling and bedform mapping was chosen to assess sand transport instead of resorting to traditional bedload-sampling programs or shear-based transport formulas. A Global Positioning System receiver is used to guide the boat over mapped gridlines while a digital sonar device records depth every second in conjunction with the recorded position. Bedform maps have been derived from points separated by 1 meter or less, with depth resolution of 1 to 2 centimeters. Riverbed profiling also documents the dynamism of riverbed channels through repeated surveys of bedforms and long bars and shoals. The mapping of bedforms and channel conditions has included 43 separate surveys of bedform grids and channel reaches, with 11 bedform-transport measurements at the Sacramento River and 4 measurements at Three Mile Slough. Reaches surveyed for general channel conditions are Sacramento River at Freeport Bend, Sacramento River from Rio Vista to Horseshoe Bend, Three Mile Slough, False River near San Joaquin River, Mokelumne River above Highway 12, and lower San Joaquin River.

This CALFED sedimentation study has derived bedform-transport rates that are an order of magnitude lower than bedload rates calculated with hydraulic methods by USGS in the 1960s and late 1970s. The measurements of bed regime in the lower Sacramento River cover a range from 20,000 to 70,000 cfs. Bedforms have been surveyed several times per year in the Sacramento River at Garcia Bend, in the lower San Joaquin River, and in Three Mile Slough.

Reports Finished and in Preparation

Buchanan, P.A., and Ruhl, C.A., 2000, Summary of suspended-solids concentration data, San Francisco Bay, California, water year 1998: U.S. Geological Survey Open File Report 00-88, 41 p.

Dinehart, R.L., Bedform movement recorded by single-beam surveys in estuarine rivers (to be submitted to journal Hydrological Processes; in review)

Dinehart, R.L., Bedform mapping in the Sacramento River (to be presented at Seventh Federal Interagency Sedimentation Conference, 2001; in review)

Dinehart, R.L., Bedform transport through Three Mile Slough (to be presented at Calfed Bay-Delta Program Science Conference 2000; in preparation)

Dinehart, R.L., and Schoellhamer, D.H., Sedimentation in the Delta of the Sacramento and San Joaquin Rivers, (USGS Web site) URL:
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Schoellhamer, D.H., Continuous Monitoring of Suspended Sediment in Rivers with Optical Sensors, (to be presented at Seventh Federal Interagency Sedimentation Conference, 2001; in review)

Schoellhamer, D.H., Suspended-sediment transport in the Delta (to be presented at the CALFED Science Conference, 2000)

Environmental Compliance Checklist

All applicants must fill out this Environmental Compliance Checklist. Applications must contain answers to the following questions to be responsive and to be considered for funding. Failure to answer these questions and include them with the application will result in the application being considered nonresponsive and not considered for funding.

1. Do any of the actions included in the proposal require compliance with either the California Environmental Quality Act (CEQA), the National Environmental Policy Act (NEPA), or both?

YES

NO

2. If you answered yes to # 1, identify the lead governmental agency for CEQA/NEPA compliance.

Lead Agency

3. If you answered no to # 1, explain why CEQA/NEPA compliance is not required for the actions in the proposal.

CEQA/NEPA compliance is not required because this is a research and monitoring project.

4. If CEQA/NEPA compliance is required, describe how the project will comply with either or both of these laws. Describe where the project is in the compliance process and the expected date of completion.

5. Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?

YES

NO

If yes, the applicant must attach written permission for access from the relevant property owner(s). Failure to include written permission for access may result in disqualification of the proposal during the review process. Research and monitoring field projects for which specific field locations have not been identified will be required to provide access needs and permission for access with 30 days of notification of approval.

LOCAL

Conditional use permit

Variance

Subdivision Map Act approval

Grading permit

General plan amendment

Specific plan approval

Rezone

Williamson Act Contract

cancellation

Other

(please specify)

None required

STATE

CESA Compliance

Streambed alteration permit

CWA § 401 certification

Coastal development permit

Reclamation Board approval

Notification

Other

(please specify)

None required

FEDERAL

ESA Consultation

Rivers & Harbors Act permit

CWA § 404 permit

Other

(please specify)

None required

DPC = Delta Protection Commission

CWA = Clean Water Act

CESA = California Endangered Species Act

USFWS = U.S. Fish and Wildlife Service

ACOE = U.S. Army Corps of Engineers

ESA = Endangered Species Act

CDFG = California Department of Fish and Game

RWQCB = Regional Water Quality Control Board

BCDC= Bay Conservation and Development Comm.

Land Use Checklist

All applicants must fill out this Land Use Checklist for their proposal. Applications must contain answers to the following questions to be responsive and to be considered for funding. Failure to answer these questions and include them with the application will result in the application being considered nonresponsive and not considered for funding.

1. Do the actions in the proposal involve physical changes to the land (i.e. grading, planting vegetation, or breaching levees) or restrictions in land use (i.e. conservation easement or placement of land in a wildlife refuge)?

YES

NO

2. If NO to # 1, explain what type of actions are involved in the proposal (i.e., research only, planning only).

This is a research and monitoring project that does not change the land.

3. If YES to # 1, what is the proposed land use change or restriction under the proposal?

4. If YES to # 1, is the land currently under a Williamson Act contract?

YES

NO

5. If YES to # 1, answer the following:

Current land use _____

Current zoning _____

Current general plan designation _____

6. If YES to #1, is the land classified as Prime Farmland, Farmland of Statewide Importance or Unique Farmland on the Department of Conservation Important Farmland Maps?

YES

NO

DON'T KNOW

7. If YES to # 1, how many acres of land will be subject to physical change or land use restrictions under the proposal?

8. If YES to # 1, is the property currently being commercially farmed or grazed?

YES

NO

9. If YES to #8, what are

the number of employees/acre _____

the total number of employees _____

10. Will the applicant acquire any interest in land under the proposal (fee title or a conservation easement)?

YES

NO

11. What entity/organization will hold the interest?_____

12. If YES to # 10, answer the following:

Total number of acres to be acquired under proposal

Number of acres to be acquired in fee

Number of acres to be subject to conservation easement

13. For all proposals involving physical changes to the land or restriction in land use, describe what entity or organization will:

manage the property

provide operations and maintenance services

conduct monitoring

14. For land acquisitions (fee title or easements), will existing water rights also be acquired?

YES

NO

15. Does the applicant propose any modifications to the water right or change in the delivery of the water?

YES

NO

16. If YES to # 15, describe _____



United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Water Resources Division
California District
Placer Hall, 6000 J Street
Sacramento, California 95819-6129
(916) 278-3000 / (916) 278-3071 Fax
<http://water.wr.usgs.gov>

May 12, 2000

CALFED Bay-Delta Program Office
1416 Ninth Street, Suite 1155
Sacramento, California 95814

Subject: Proposal for next phase funding of the CALFED project "Sedimentation in the Delta and Suisun Bay"

This project does not include any physical action on the ground and therefore is exempt from the local notification requirement. This research and monitoring project utilizes already existing monitoring stations operated by the USGS and DWR.

Sincerely,

David H. Schoellhamer, Ph.D.
Research Hydrologist

NONDISCRIMINATION COMPLIANCE STATEMENT

STD. 19 (REV. 3-95)

COMPANY NAME

United States Department of the Interior, Geological Survey

The company named above (hereinafter referred to as "prospective contractor") hereby certifies, unless specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code of Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and the development, implementation and maintenance of a Nondiscrimination Program. Prospective contractor agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, physical disability (including HIV and AIDS), medical condition (cancer), age (over 40), marital status, denial of family care leave and denial of pregnancy disability leave.

CERTIFICATION

I, the official named below, hereby swear that I am duly authorized to legally bind the prospective contractor to the above described certification. I am fully aware that this certification, executed on the date and in the county below, is made under penalty of perjury under the laws of the State of California.

OFFICIAL'S NAME

Michael V. Shulters

DATE EXECUTED

May 12, 2000

EXECUTED IN THE COUNTY OF

Sacramento

PROSPECTIVE CONTRACTOR'S SIGNATURE

PROSPECTIVE CONTRACTOR'S TITLE

District Chief

PROSPECTIVE CONTRACTOR'S LEGAL BUSINESS NAME

United States Department of the Interior, Geological Survey